Space Weather Technical Forecast

Issued on Wednesday, 12 July 2023 at 13:28 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: High activity with further M-flares (R1-R2 blackouts) expected. Slight chance X-class flares. Chance G1-G2 Minor/Moderate storms day 2-3 (13-14 Jul) due to CME and CH effects.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: High, with three R2 blackouts, seven R1 blackouts and twelve sunspots on the disc. The strongest flares were M6.9, peaking 12/0955 UTC, M6.8 peaking 11/1808 UTC and M5.8 peaking 11/2215 UTC all from AR3372 on the northeast limb. This is a large region with significant magnetic looping evident, but remains difficult to assess due to its location. More complexity is likely to become apparent it moves into a less oblique viewing angle. A number of smaller M-flares have been observed from other regions on the disc, including AR3361 in the northwest, and AR3366 and AR3368 in the southwest. Large and mature sunspot AR3363 is the other region of interest, with ongoing development including mixed polarity spots developing around its periphery and a weak delta being apparent in its northern penumbral extent. Despite the current lack of activity from this region, its strong magnetic field gives the potential for M or X-class flares.

A CME was produced from a filament eruption to the south of AR3363 around 11/1830 UTC, with a partial halo main CME but also a large asymmetric halo shock. The bulk of the material has been assessed as passing mainly below Earth, but with a likely glancing blow occurring on day 3 (14 Jul).

Solar Wind / Geomagnetic Activity: The solar wind as observed at L1 by ACE/DSCOVR, was indicative of slow wind conditions, with background speeds, below 350km/s. The density was below average to average. Total magnetic field strength (IMF, Bt) has been weak to moderate throughout, between 5 nT and 9 nT, whilst the north-south component was mainly negative (southward), with minimum -6nT except for the period 11/1500-1800 when it became mostly positive with maximum +6 nT. The phi angle has been predominately positive (away from the Sun). Geomagnetic activity has been at Quiet throughout (Kp 1-2).

Energetic Particles / Solar Radiation: High energy proton flux (greater than 10MeV), as observed by GOES16, has been at background and well below the S1/Minor Storm level. High energy electron flux (greater than 2MeV), as observed by GOES16 was at Background to Moderate, peaking 846 pfu at 11/1555 UTC. The 24-hour integrated fluence was below the Active (1e8 integrated pfu) threshold on a steady trend. A fluence of 1.96e7 pfu was recorded at 12/0000UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: Moderate to High activity expected with further M-class flares expected and a slight chance of X-class flares.

Solar Wind / Geomagnetic Activity: A partial halo CME, associated with the M2 flare on 10 Jul, was seen travelling towards the southwest in coronagraph imagery with an Earth directed shock component is considered probable. At this stage, an arrival time of around 13/0600 UTC is most likely, but confidence is rather low. A further glancing CME arrival is expected during the

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first half of day 3 (14 Jul) due to the filament eruption on the 11 Jul. Otherwise background solar wind is expected to become enhanced due to the arrival of the HSS from CH23/- day 2 (13 July). The combination of CME effects and HSS could lead to increased geomagnetic impacts. Geomagnetic activity is forecast to be Quiet (Kp 0-2) at first, becoming Active to G1/Minor Storm (Kp 4-5) with a small chance of G2/Moderate Storm intervals (Kp 6) day 2 (13 July). Conditions likely easing for a time, before rising again to give a chance of G1-G2 Minor to Moderate storms with the second CME glance on day 3 (14 Jul). Activity then easing to Quiet to Active day 4 (15 Jul).

Energetic Particles / Solar Radiation: The high energy (greater than 10MeV) proton flux has a slight chance of reaching the S1/Minor Storm threshold through the period, should any larger flares occur. High energy electron flux (greater than 2MeV) is likely to remain at Background to Moderate day 1-2, before any CME or CH arrival. These are likely to enhanced increase flux values once solar wind pressure eases later in the period, giving a chance of Moderate to High levels by day 4 (15 Jul). Electron fluence is expected to remain below the Active threshold (1e8 integrated pfu) for much of the period, but with a chance of rising above by the end of day 4 (15 Jul).

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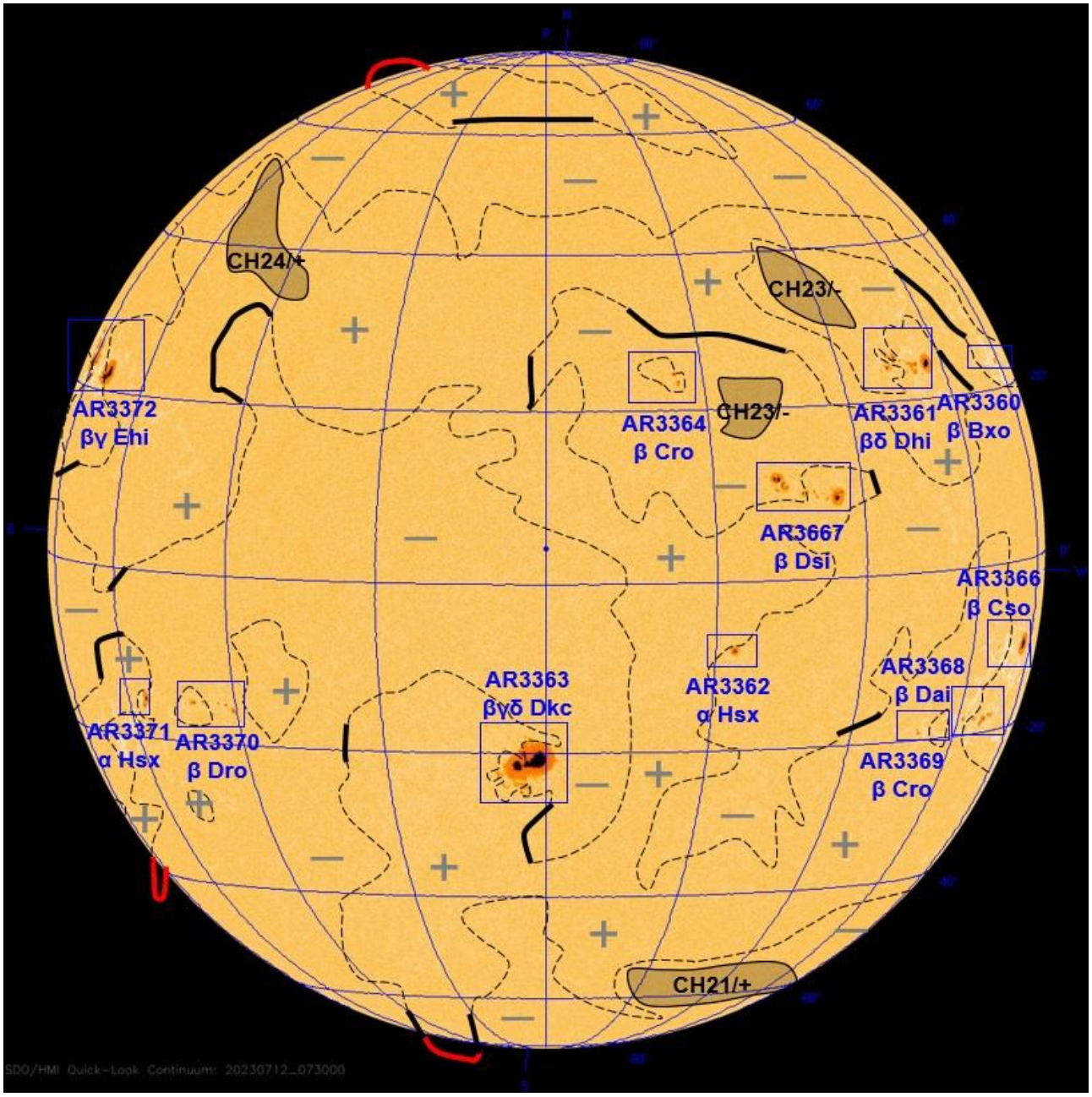
Figure 1. Solar Analysis Valid 12/0800 UTC.



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Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

A partial halo CME associated with the M2 flare early on 10 July was seen travelling towards the southwest in coronagraph imagery. There was also a fainter asymmetric full halo from the shock. Although the bulk of the CME is expected to pass ahead of Earth, an Earth directed shock component is considered probable. At this stage, an arrival time of around 13/0600 UTC is most likely, but confidence is rather low.

A further CME was observed from a filament eruption to the south of AR3363 in the south-central disc at 11/1830 UTC. The bulk of this material is also expected to miss, most likely passing to the south of Earth, however a shock was again observed with some component heading north of the solar equator. This likely arriving at Earth, with a glancing impact during the first half of day 3 (14 Jul).

Otherwise, current background speeds due to ongoing slow wind environment are expected to become enhanced day 2 (13 Jul) due to the arrival of the fast wind of CH23/-. On the previous rotation this feature resulted in solar winds reaching 600-700 km/s, and a maximum geomagnetic response of G2/Moderate storm. However, on this rotation the CH is smaller and fragmented with lower confidence of reaching these speeds or response. However, the combination of CME effects and HSS could lead to increased geomagnetic impacts.

Geomagnetic activity is forecast to be Quiet (Kp 0-2) at first, becoming Active to G1/Minor Storm (Kp 4-5) with a small chance of G2/Moderate Storm intervals (Kp 6) due to CME and HSS effects on day 2 (13 July). A decrease is then possible for a time, before rising to give a chance of G1-G2 Minor to Moderate storms with the second CME glance on day 3 (14 Jul). Activity then easing to Quiet to Active day 4 (15 Jul).

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	10	30	40	10
Strong	G3	No	1	5	10	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
10/1107	Halo shock	M2 AR3366	SW	900 km/s	13/0600 -6/+9 hrs	Glancing impact Low confidence
11/2335	Halo shock	Filament S of AR3363	SE	870 km/s	14/1200 +/-9hrs	Glancing impact. Low confidence

Figure 2: Enlil and Ensemble

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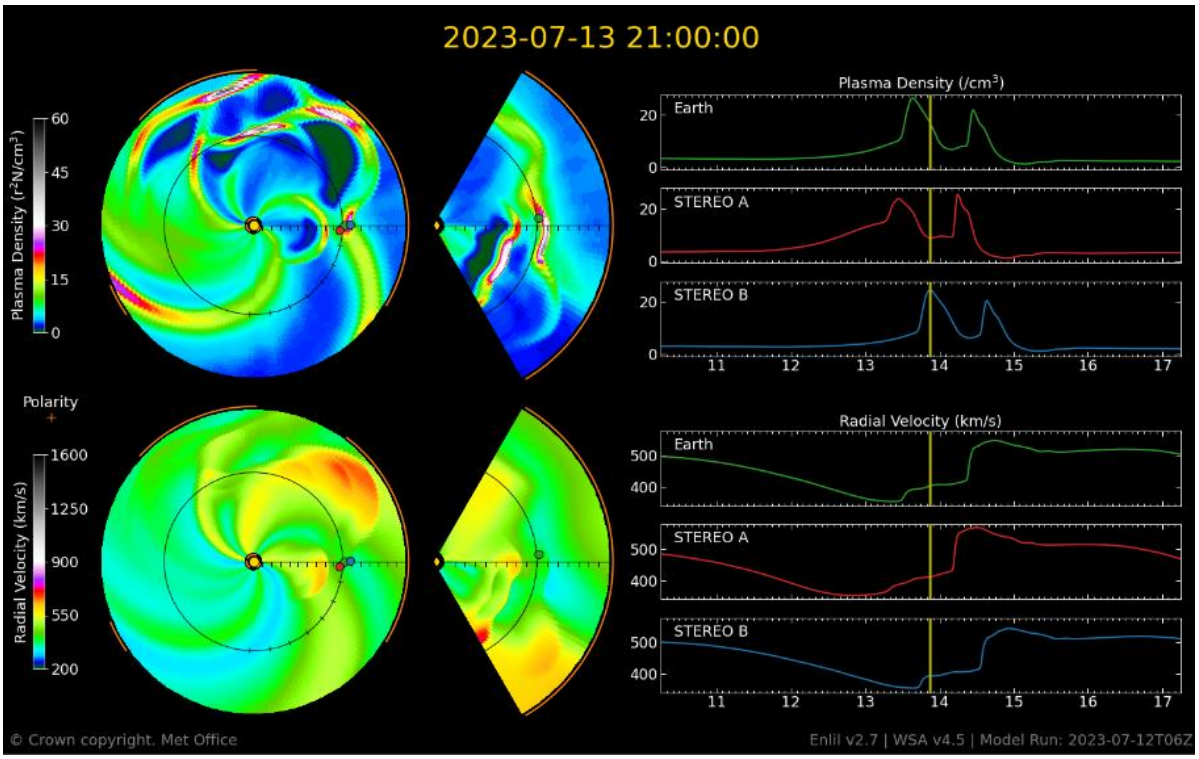

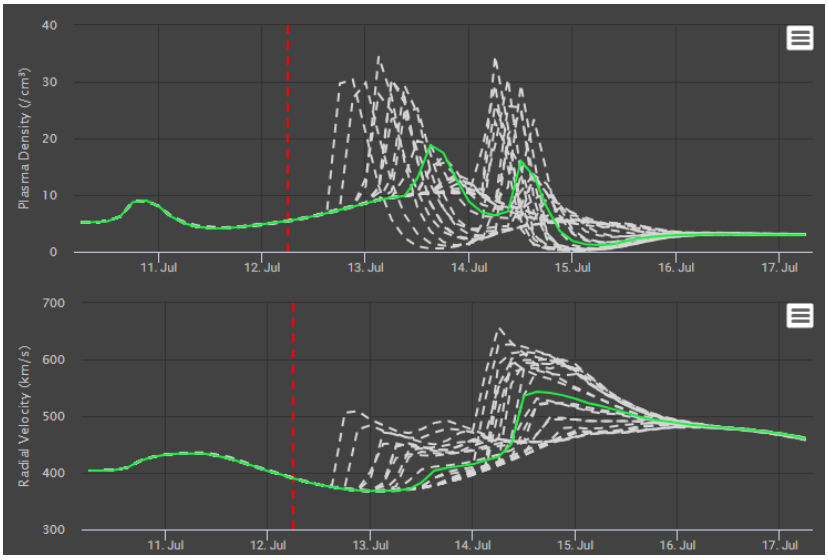

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Radio Blackouts - X-Ray Flares:

There are twelve sunspot regions with Moderate to High activity expected to continue, giving further M-flares and a slight chance of X-flares.

The majority of the larger flares have been AR3372 near the NW limb. This is currently too close to the limb for a complete analysis, but appears to be a large and magnetically complex region with strong magnetic looping evident in SDO imagery, with further flaring likely. The other M-flare sources in the last 24 hours were AR3361, AR3366 and AR3368. AR3361 is a smaller region in the northeast disc, but with a very small delta-spot (reverse polarity spot) in its trailer region. AR3366 is a simplifying region near the southwest limb and AR3368 is a small bipolar region following this in the southwest.

Also of note is large region AR3363 in the central southern disc. This is a magnetically strong, but mature region primarily composed of large negative umbra that has split, potentially signaling some weakening. However this process has been accompanied with mixed-polarity small spots developing around its periphery, and the emergence of a delta spot on the northern edge of its penumbra. This complexification increases the potential instability of the spot, despite its potential weakening, and given the strong magnetic fields associated with it, isolated M or X-flares are possible.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	80	80	70	60
Very Active	R3 to R5 X Class	No	20	20	15	10

Figure 3: GOES-16/18 X-ray Flux

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Solar Radiation Storms - (High Energy Protons):

The high energy (greater than 10MeV) proton flux, as observed by GOES16, is currently near background and is likely to remain at this level. There is a chance of this rising towards the S1 Minor Radiation storm level, with a slight chance of exceeding it, given any significant flaring from the large number of spots on the western disc. This most likely to come from AR3363 as it moves into the western disc, or any of the other smaller regions currently approaching the western limb.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	10	10	10	10
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

High Energy Electrons Event (≥ 2MeV):

High energy electron flux (greater than 2MeV) at GEO is varying diurnally between Background and Moderate levels. The next influx of electrons into the Van Allen belt is expected to occur with the combined effect of the CME arrivals on 13 and 14 Jul and the potential CH enhancement on 13 Jul. Once any initial solar wind pressure eases from any of these enhancements the observed flux is expected to rise to Moderate, perhaps High levels, mainly later day 3 (14 Jul) or day 4 (15 Jul).

The associated 24 hour fluence is expected to remain below the Active threshold (1e8 total flux), with REFM giving a good guide. However, beyond day 2 (12 Jul) REFM is expected to become unreliable due to any CME or CH influences that occur. Fluence is expected to rise in response, with a chance of breaching the Active level by the end of day 4 (15 Jul).

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	1	1	10	30
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

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